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Quality & Performance Optimization through GAN-based Anomaly Detection : Industrial & Medical Use Cases Arnaud Bougaham¹, Benoît Frénay¹ and Isabelle Linden²

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Context

- Industrial sector evolved with technologies : current era of cyber-physical systems / Industry 4.0.
- Advanced anomaly detection : crucial quality control step / important part of Industry 4.0 opportunities.
- Traditional algorithms suffers from practical drawbacks like high false positive rates and human misjudgment.



² Research Questions

- What are the best deep learning techniques to detect anomalies that exist in real-world industrial datasets? (unsupervised learning, high-resolution images, imbalanced datasets, etc.)
- How to integrate the business constraints (full TPR, acceptable inference time, worker interactions, explainable decisions, etc.) into a binary normal/abnormal classification algorithm?

🚊 Methods & Materials

First Idea GanoDIP [1]:

- Train a Generator and a Discriminator through a GAN framework. Place the networks in an autoencoder architecture in order to train an Encoder.
- At the inference step, an anomaly score qualifies the differences on the residual image, after a patching technique that highlights the differences.



Second Idea VQGanoDIP [2]:

- Represent the images as a composition of coherent and rich details in the latent space, through a Vector Quantized GAN.
- Statistics on the residual image and the networks losses quantify how the image is different from the normality.
- A binary extra tree classifier is finally used to discriminate between normal and abnormal products.



Another approach developed [3]:

- Take the few abnormal data available into consideration, in order to train a cycle-GAN.
- Industrial and medical datasets have been considered.





Results

 [2] VQGAN-based approach on the PCBA dataset : Regular accuracy = 95.69%.

Zero-False-Negative accuracy = 87.93%.



Zero-False-Negative accuracy = 85.4%.

[3] CycleGAN-based approach on the texture-shaped industrial & medical datasets :

	General Impro	Hourid Hope		Absorbationages		Abromatimaged				monuny		internary	00000 - 0000
	1		1				Dataset	Domain	Type	ZFN thr.	ACC thr.	ZFN thr.	ACC thr.
-					-		Wood	Indust.	Texture	93.33	95.00	73.33	83.33
					-		Tile	Indust.	Texture	100.00	100.00	89.02	97.56
-			-	THE REAL PROPERTY OF	-		Hazelnut	Indust.	Object	100.00	100.00	72.86	94.29
	Breast	PDAM Itemal maps		Resita	100	Brain Normal Instant	Screw	Indust.	Object	50.83	57.50	52.50	52.50
	Anona maga			Apoind imper			Breast	Med.	Texture	65.15	93.18	87.12	94.70
1.00	1		ş				PCAM	Med.	Texture	94.41	97.79	82.42	99.89
							Retina	Med.	Texture	52.17	96.54	50.29	95.46
-					- /		Brain	Med.	Object	51.02	62.24	62.24	68.37
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Figure 6: Qualitative and Quantitative Results for the CycleGAN Approach

C Future Works & References

- Different Generative Networks will be considered to improve the residual image generation to focus on the real anomalies.
- The quality constraint will be applied directly at the training step as a future work. The Augmented Lagrangian Method is under study to improve the current performance.
- The method integration into the real-world production line will also be explored, considering the company philosophy, constraints, and the workers' habits.



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[1] Bougaham, A. et al. (2021). GanoDIP - GAN Anomaly Detection through Intermediate Patches: a PCBA Manufacturing Case. PMLR.

- [2] Bougaham, A. et al. (2022). Composite Score for Anomaly Detection in Imbalanced Real-World Industrial Dataset. arXiv preprint.
- [3] Bougaham, A. et al. (2023). Industrial and Medical Anomaly Detection Through Cycle-Consistent Adversarial Networks. arXiv preprint.



Figure 6:

Regular accuracy = 97.2%.